нічної оболонки визначаються за допомогою метода послідовних наближень.

ЛІТЕРАТУРА

1. Власов В.З., Леонтьев Н.Н. Балки, плиты и оболочки на упругом основании. - М.: Физматгиз, 1960. - 491 с.
2. Климанов В.И., Литвиненко А.Г., Каваева В.П. Конические фундаменты – оболочки. – М.: Стройиздат, 1988. – 127 с.
3. Flügge W. Powłoki oblczenia statyczne. – Warszawa: Arkady, 1972. – 510 s.
4. Зенкевич О. Метод конечных элементов в технике. – М.: Мир, 1975. – 544 с.
5. Немчинов Ю.И. Метод пространственных конечных элементов с применением к расчету зданий и сооружений. – К.: НДІБК, 1995. – 368с.
6. Bakker M.C.M., Pekoz T.The Finite Element Method for Thin-Walled Members – Basic Principles // Third International Conference on Thin-Walled Structures. – Elsevier. – 2001. – P.417-425.
7. Вольмир А.С. Гибкие пластины и оболочки. - М.: Гостехиздат, 1956. – 419 с.
8. Запорожец Е.В. Расчет методом конечных элементов осесимметричного изгиба гибких конических оболочек, расположенных на упругом основании // Вісник Придніпровської державної академії будівництва та архітектури. – Дніпропетровськ: ПДАБтаА, 2004. -№ 3. – С. 24 – 29.

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STUDY OF HETZIAN STRESS CONTACT THEORY AND FEA STRESS-STRAIN STATE CONVERGENCE

K.A. Ziborov[1], D.A. Kohonova[2], V.V. Protsiv[3]

[1]associated professor, M.SC., professorб Head of the Department of Machinery Design Fundamentals, State Higher Educational Institution "National Mining University", Dnepropetrovsk, Ukraine, e-mail: ziborov@nmu.org.ua.

[2]junior research assistant, Department of Mining Engineering, State Higher Educational Institution "National Mining University", Dnepropetrovsk, Ukraine, e-mail: kohanova.d.a.@gmail.com

[3]Ph.D., Professor of the Department of Machinery Design Fundamentals, State Higher Educational Institution "National Mining University", Dnepropetrovsk, Ukraine

Abstract. Theoretical study of a convergence of a deformable body stress state, which is obtained by different approaches, provided in the paper. The following methods are used: Hertzian stress contact theory and finite element analysis. As a result of the research, high convergence of both calculation approaches is reached.

Key words: convergence, finite element analysis, Hertzian stress contact theory, deformable body.

ИССЛЕДОВАНИЕ СХОДИМОСТИ РЕЗУЛЬТАТОВ ТЕОРИИ ГЕРЦА И НАПРЯЖЕННО-ДЕФОРМИРОВАННОГО СОСТОЯНИЯ, РЕШЕННОГО ПРИ ПОМОЩИ МЕТОДА КОНЕЧНЫХ ЭЛЕМЕНТОВ

К.А. Зиборов[1], Д.А. Кохонова[2], В.В. Процив[3]

[1]кандидат технических наук, доцент, заведующий кафедрой основ конструирования механизмов и машин Государственного ВУЗ «Национальный горный университет», Днепропетровск, Украина, e-mail: ziborov@nmu.org.ua.

[2]младший научный сотрудник кафедры горной механики Государственного ВУЗ «Национальный горный университет», Днепропетровск, Украина, e-mail: kohanova.d.a.@gmail.com

[3]доктор технических наук, профессор кафедры основ конструирования механизмов и машин, Государственного ВУЗ «Национальный горный университет», Днепропетровск, Украина

Аннотация. В работе приведены результаты теоретического исследования сходимости функции контактных напряжений деформируемого тела, полученных различными методами. Использованы следующие теории и методы: теория Герца об упругом контакте, конечно-элементный анализ. В результате исследования получена достаточная сходимость обоих способов расчета.

Ключевые слова: сходимость, конечно-элементный анализ, теория Герца об упругом контакте, деформируемое тело.

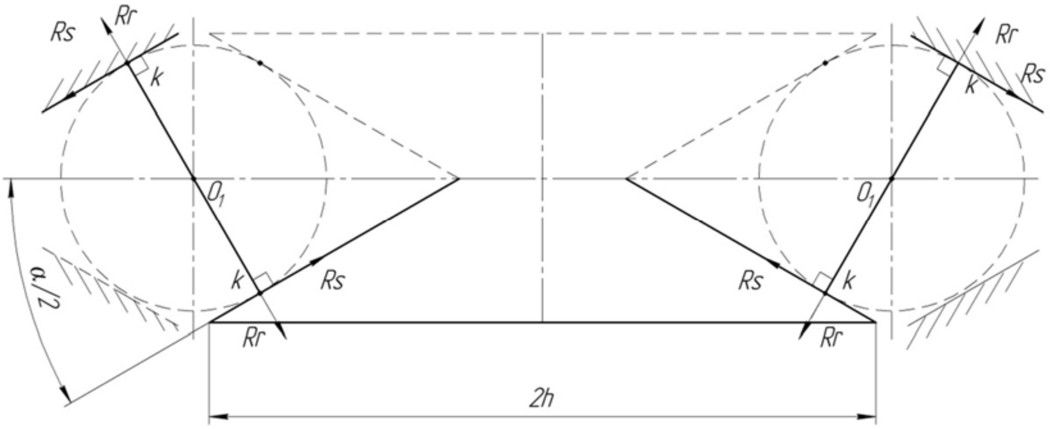
Introduction. The usage of a new wheel set with additional kinematical movability [1] caused another force distribution within the axle-box, that varies from the conventional one. Thus, there is necessary to calculate force distribution in order to reduce weaknesses and set up the relations between arising stress and influencing forces.

Furthermore, the innovative contact pair cone-sphere demands to be studied subject to contact stress. The axle-box (pic. 1) of wheel-set consists of a bushing, which mounts in wheel center. On the ends of the bushing the cone cavities are produced. Into these cavities two spheres are mounted.

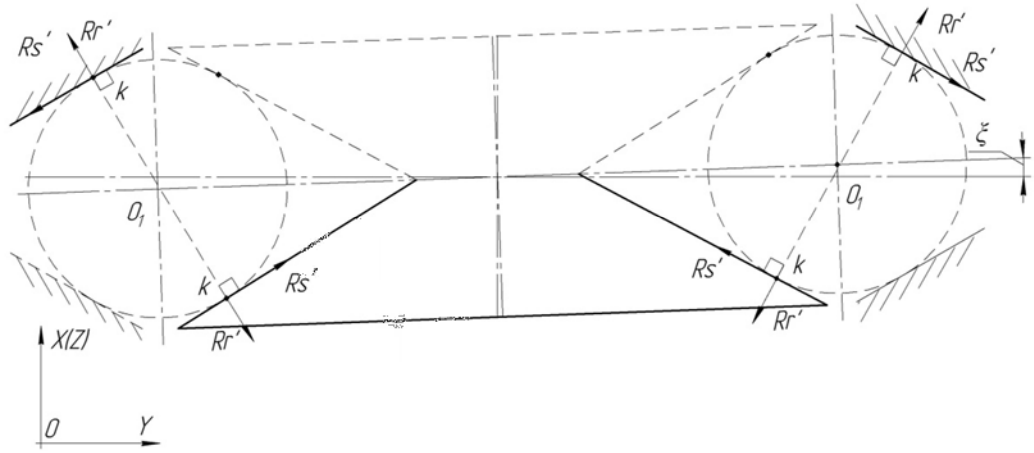
However, to calculate the reaction of a sphere and cone surface while oscillating loads is not able owing to statically indeterminate system. In order to evaluate the reactions we can provide some rough calculations, but the exact values of acting forces can not be obtained. That is why the ***purpose of the paper*** is to find out the most appropriate method for stress calculation.

The usage of FEA will give more accurate values for each finite element both for contacting pair and axle-box elements.

The conventional method to define stress in pair cone-sphere demands the usage of Hertzian stress contact theory. The application of the theory will give accurate results, but during design or stages of its improvement can occur such conditions, when it is necessary to study the stress, which arises in another layers (contacting welding etc.)



a



b

Figure 1 – The scheme of force distribution within the axle-box while symmetrical (a) and asymmetrical loading appliance. 2*h* – the length of the bushing; R_r – radial load; R_s– axial load; *k* – contact area; *α* – elevation angle of cone surface; O_1 – momentary geometrical center of the sphere location

Thus, in the paper we purport to define the convergence between conventional calculation and by FEA.

On the pic. 2 is depicted the FEA model of the whole wheel-set to clarify the design and contacting pair location.

As we can see on the fig. 3, the rough calculation of the stress in the contacting pair account 68 MPa.

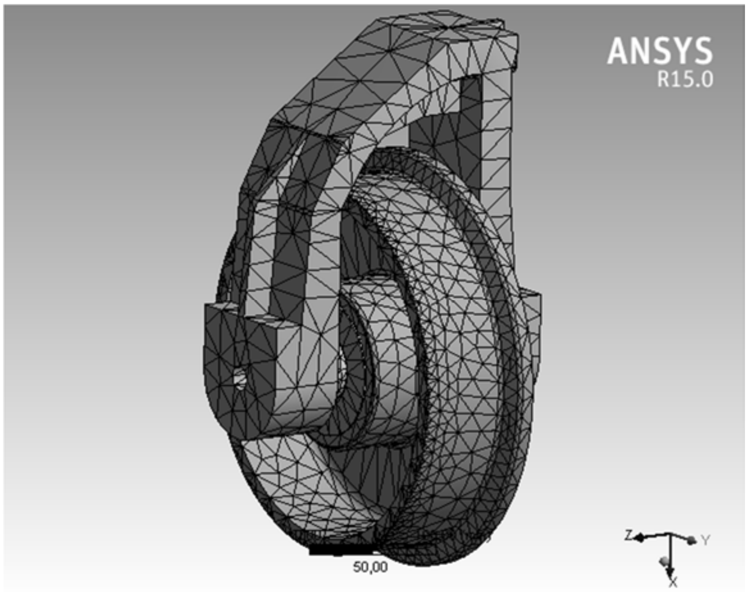


Figure 2 – Wheel-set design and its finite element model

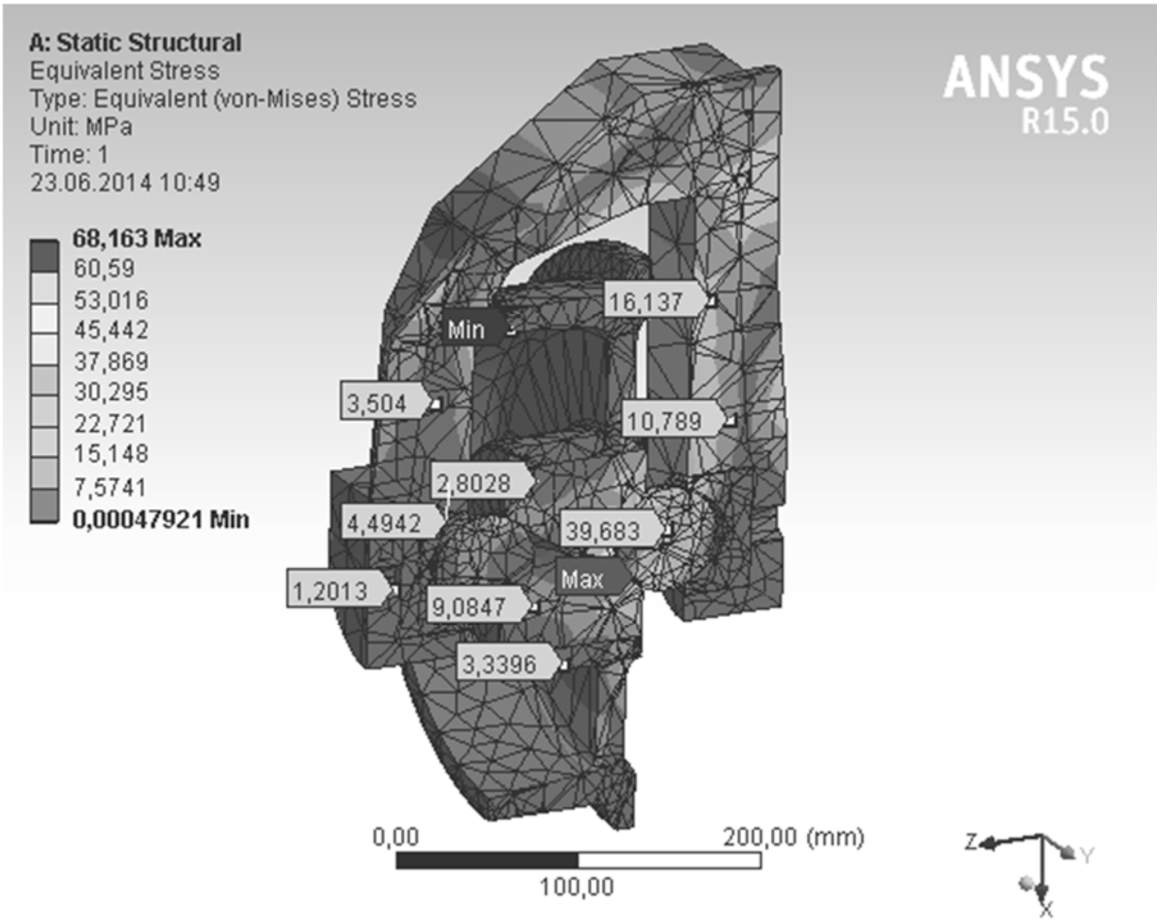


Figure 3 – Stress-strain state of axle-box

But we have to take into account, that contact stress can be much higher owing to insignificant contacting area. The width of contact area calculates by the following relation:

$$a = 1{,}6\sqrt{F_r D_k \left(\frac{1-\mu_1^2}{E_1} + \frac{1-\mu_2^2}{E_2} \right)}, \quad (1)$$

where μ_1, μ_2 – Poisson ratio; E_1, E_2 – modulus of elasticity, Па; F_r – pressing force, N; $D_к$ – diameter of contact area circle, m.

The calculation shows that for sphere 60 mm in diameter and 60º elevation angle of a cone the contact width is 0,62 mm. Maximum stress according to relation (2) is 182 mm.

$$\sigma_{\max} = 0{,}798\sqrt{\frac{F_r}{D_k \left(\frac{1-\mu_1^2}{E_1} + \frac{1-\mu_2^2}{E_2} \right)}}. \quad (2)$$

Using FEA (3) we have simulated the contact with the same conditions.

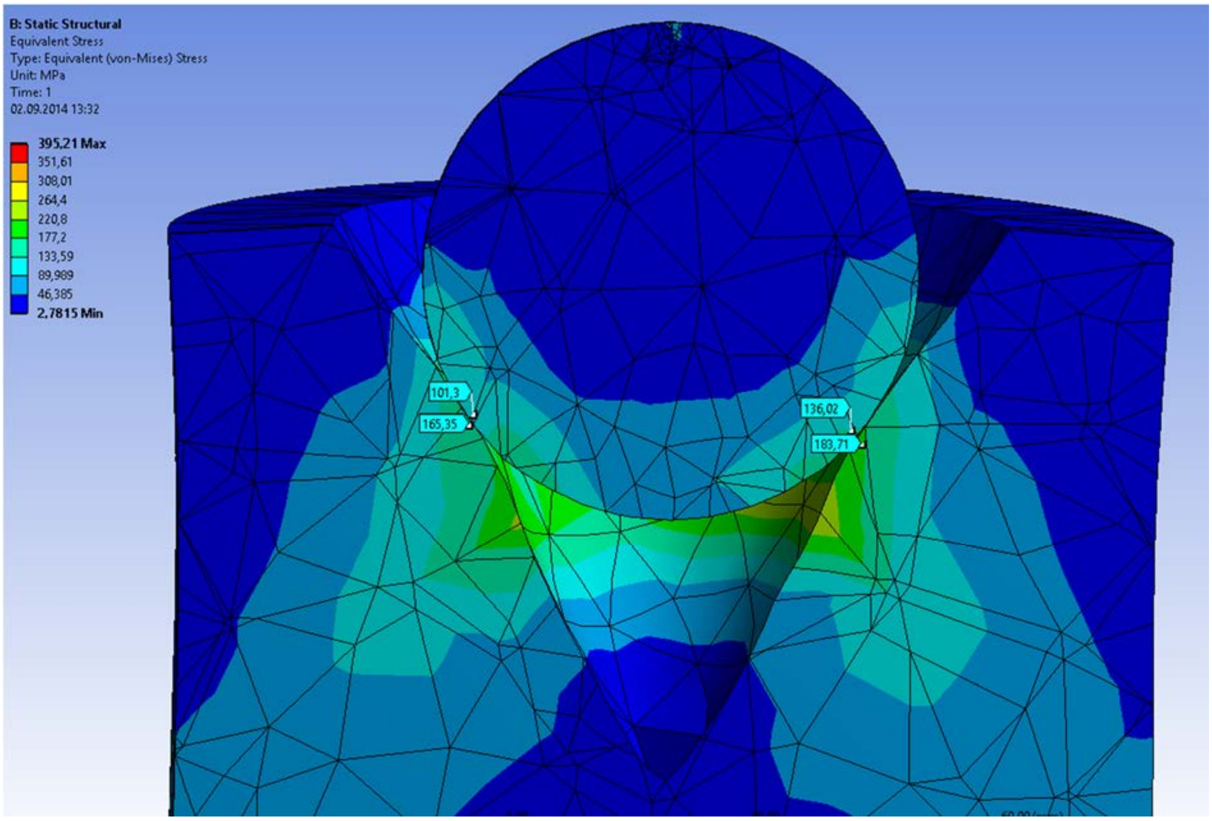


Fig. 4. Simulation of Hertzian contact via FEA

As we can see, the biggest stress in the contact area is 181 MPa. To find out the convergence lets calculate several pairs and compile a graphic relation between conventional solution and FEA.

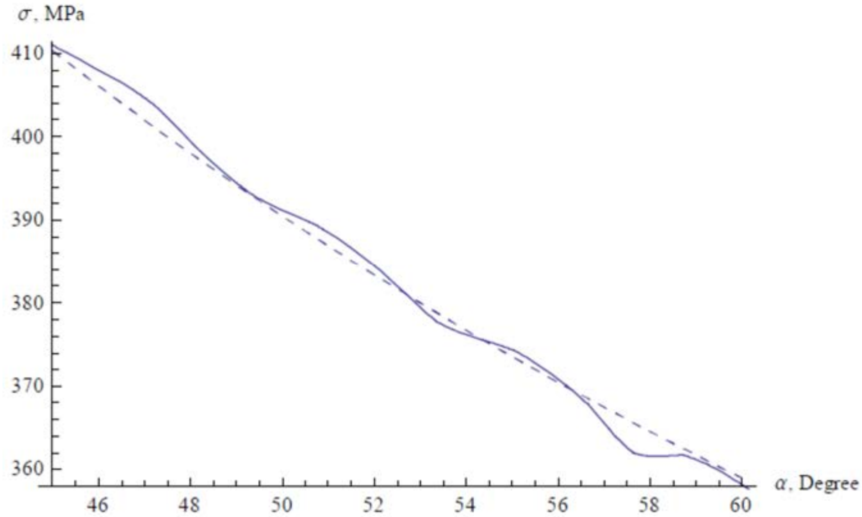


Figure 5 – Convergence of stress relative to sphere diameter
———— FEA; ------- conventional simulation

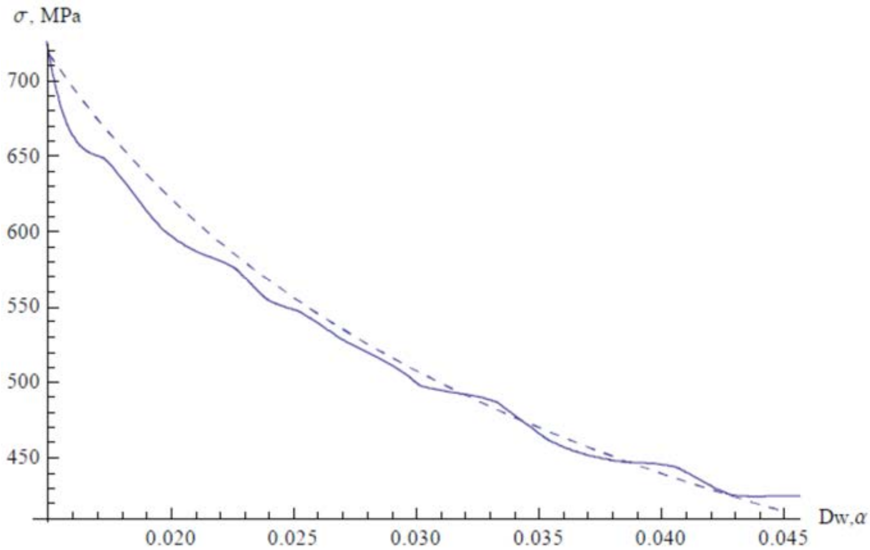


Figure 6 – Convergence of stress relative to elevation angle of the cone
———— FEA; ------- conventional simulation

As the analysis of the relations on the fig. 5 shows, the convergence of FEA and Hertzian stress is achieved up to 85 %. So, while designing a wheel-set.

Conclusions. From the above we can conclude, that usage of the finite element models while contact stress simulating is more appropriate instead of the Hertzian contact stress theory because of time saving and visual control, that helps to increase accuracy. Therefore, application of the FEA stress contact analysis while designing a new contact pair, which contacts by the line or a tiny surface will help to study neighbor construct elements, external force influence onto contact stress, life of the pair.

In this paper we showed just an example of our scientific projects. The Laboratory of the Department of Machinery Design Fundamentals provides a wide range of structural calculations using a lot of mathematical and simulation software. We propose a service in the field of machinery, solution of different problems concerning mechanical, control system and other equipment's issues.

REFERENCES

1. Johnson, K.L. (1985) Contact Mechanics, Cambridge University Press, 1985.
2. Xiaolin, C., Yijun, L. Finite Element Modeling and Simulation with Ansys Workbench, CRC Press, 2014, 411 p.

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МЕТОДИКА ПОПЕРЕДНЬОЇ ОБРОБКИ ЕКСПЕРИМЕНТАЛЬНИХ ДАНИХ

В.С. Ловейкін[1], Ю.О. Ромасевич[2]
[1]доктор технічних наук, завідувач кафедри конструювання машин, Національний університет біоресурсів і природокористування України, м. Київ, Україна
[2]кандидат технічних наук, докторант кафедри конструювання машин, Національний університет біоресурсів і природокористування України, м. Київ, Україна, e-mail: d.um@mail.ru

Анотація. В роботі наведено алгоритми попередньої обробки експериментальних даних, які представлені у вигляді багатомірного масиву. Розроблені алгоритми дозволяють автоматично визначати моменти початку та закінчення досліджуваного процесу, виконувати калібровку нуля, згладжувати дані та формувати двомірні масиви „час - вимірювана величина”.

Ключові слова: експериментальні дані, масив, обробка, цикл.

METHODS OF EXPERIMENTAL DATA PRETREATMENT

Vyacheslav Loveikin[1], Yuriy Romasevich[2]
[1]Doctor of technical Sciences, Head of Department of Machinery Design, National University of Life and Environmental Sciences of Ukraine, Kyiv, Ukraine
[2]Ph.D., Doctoral candidate of Department of Machinery Design, National University of Life and Environmental Sciences of Ukraine, Kyiv, Ukraine, e-mail: d.um@mail.ru

Abstract. The algorithms for experimental data preprocessing presented in the form of a multidimensional array are stated in the article. The designed algorithms allowed automatically to determine the start and end points of studied process, to perform calibration of zero, to smooth the data and to form two-dimensional arrays „time - measured value”.

Keywords: experimental data, array, processing, cycle.